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Case study "Impact of fisheries and the physical pressure from fisheries on the fish diversity and the seabed habitats"

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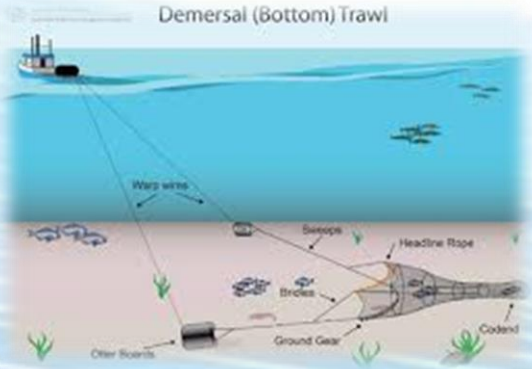
BACKGROUND

Different human activities exert a wide range of pressures on the seabed and have impact on habitats and species. In order to assess the impacts, the spatial and temporal interactions of biodiversity and habitats sensitivity to human activities need to be studied.

AIM: To carry out an in-depth analysis of the physical pressure on the seafloor from fisheries (from VMS data) and its impact on benthic communities and fish diversity. Different mobile fishing gear (beam trawl, OTM trawl) pressure is assessed and related to the available data on fish and benthic diversity. Areas affected by fishing pressure are identified and mapped.



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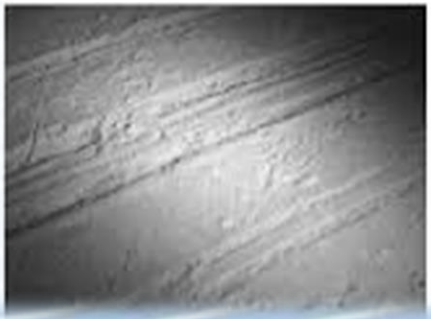
INTRODUCTION:

Aiming at assessing the seabed habitats exposure and sensitivity in the Bulgarian Black sea coastal and shelf waters the present methodology was introduced and implemented. Demersal fishing was recognized as the most significant activity associated with physical disturbance of the seabed habitats.

To derive the physical pressure on benthic habitats from fishing activities of vessels equipped with mobile bottom contact fishing gears, Vessel Monitoring data (VMS data) was used, provided by satellite tracking of fishing vessels.



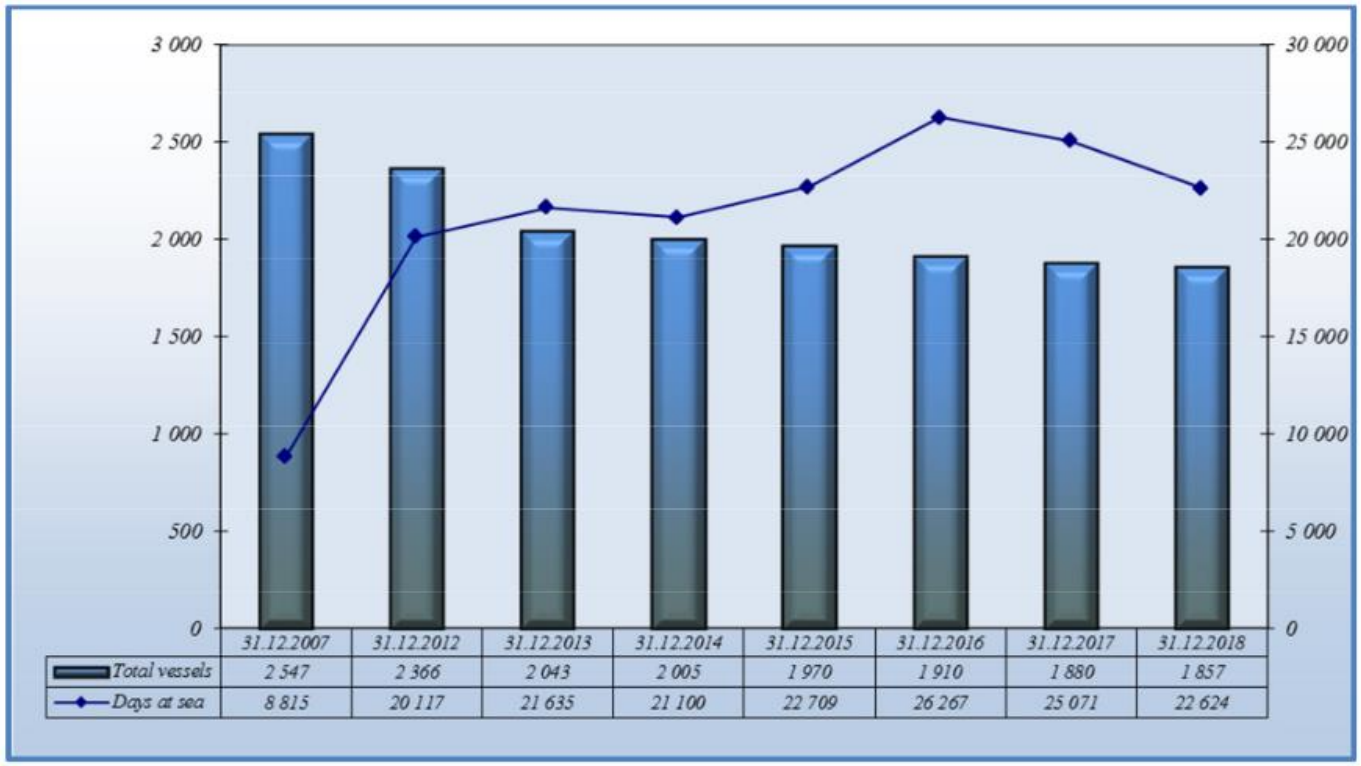
Bulgarian fishing fleet

Bulgarian vessels operate in Black sea only and in 2017 consists of 1880 (active 1295) vessels, including segments :

- under 6 m
- from 6 to 12 m
- from 12 to 18 m
- from 18 to 24 m
- over 24 m

95 % (1788) are less than 12 m

Number of vessels and days at sea during the period 2007-2018 (NAFA, 2019)



	31.12.2007	31.12.2012	31.12.2013	31.12.2014	31.12.2015	31.12.2016	31.12.2017	31.12.2018
Total vessels	2 547	2 366	2 043	2 005	1 970	1 910	1 880	1 857
Days at sea	8 815	20 117	21 635	21 100	22 709	26 267	25 071	22 624

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VMS equipment

Since 2006, Bulgaria equipped 99 fishing vessels with length overall ≥ 12 m with satellite tracking devices. For better control of turbot catches from 2012 Bulgaria equipped additionally 77 fishing vessels with length overall under 12 m. with tracking devices (type ET-100F) using GSM/GPRS connection to the FMC servers.

The Inmarsat-C and Inmarsat-D networks provide global coverage and GSM/GPRS network provides coverage of Bulgarian territorial waters and adjacent zones in the Black Sea. The implemented networks enable two-way data communication between any fishing vessel and the FMC at any time. The network is operational at all times (24/365).

Target species

Pelagic fish

European sprat (*Sprattus sprattus*), Mediterranean horse mackerel (*Trachurus mediterraneus*), Atlantic bonito (*Sarda sarda*), Bluefish (*Pomatomus saltatrix*).

Demersal fish species

Red mullet (*Mullus barbatus*), Picked dogfish (*Squalus acanthias*), Thornback ray (*Raja clavata*), Turbot (*Scophthalmus maximus*), Gobies nei (*Gobiidae*).

Shellfish

Rapa whelk (*Rapana venosa*), clams (target sp. *Donax trunculus*, *by-catch Chamelea gallina, Donacilla cornea*)

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Material and Methods

Study area:

Bulgarian Black Sea shelf area at depths 0 -100 m with total area of 10007.13 km^2, where the fishing activities are concentrated.

DATA:

- data from national fisheries statistics (NAFA, 2017) was used to ensure selection of vessels operating with mobile fishing gears;

- Data on potential fishing routes and fishing effort, registered by VMS by days and vessels during the period January 2017 – September 2017 were extracted by filtering database by vessel' speed. Only routes with a fishing operations specific speed between 1.6 and 3.6 knots were selected.

GEARS:

The mobile fishing gears (OTM trawl, beam trawl) sweeps a well-defined path, the area of which is the length of the path times the width of the trawl, called the "swept area" or the "effective path swept". Bulgarian fishing vessels usually use OTM trawls with effective part of head rope of 10 – 12 m and two beam trawls together in one haul with lengths of 4.5 – 6 m each. An average width of 11 m for both types of fishing gears was used for the present study.

Estimating physical pressure from fisheries

For the estimation of physical pressure, it was necessary to provide a spatially resolved index of fishing intensity for mobile bottom contacting gears. Fishing intensity is defined as the area swept per unit area, i.e. the area of the seabed in contact with the fishing gear in relation to a surface area of the grid cell.

Generally fishing intensity is based on VMS and fisheries logbook data. In its raw format, VMS data are geographically distinct points, so-called "pings", providing information about the vessel, its position, instantaneous speed and heading.

Assessment period :

- For benthic habitats – aggregated pressure between Jan and Sept 2017 due to sampling for zoobenthos carried out in Oct 2017.

- for fish - aggregated pressure between Jan and Sept 2017 with respect to the sampling period (Oct - Nov 2017)

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VMS data processing

VMS data was provided in the form of 24-hours reports and 8720 reports were analyzed; as a result 86 out of 130 vessels were identified to have been actively involved in fishing activities at fishing specific speeds varying from 1.6 to 3.6 knots (considered indicative for active fishing).

Reporting frequency:

for vessels with length overall above 15m - 1 report per hour;

for vessels within the range 12 to 15 m length overall the reporting frequencies varied in an extremely wide range – from 1 report per 15-10 minutes to 8 reports per minute resulting in high volume of VMS data to be analyzed.

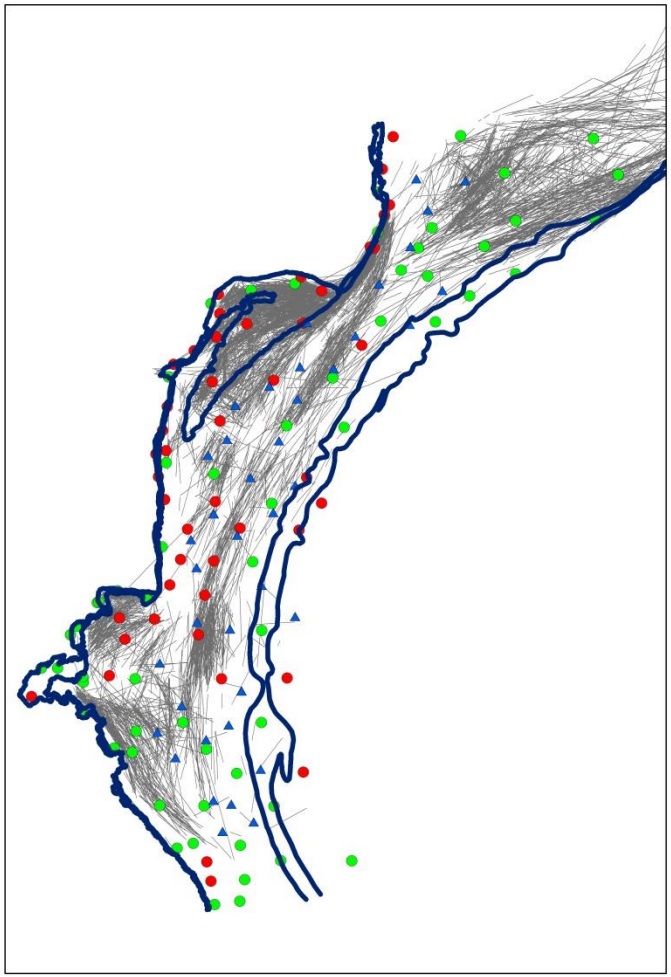
Electronic logbook data:

***was not available*, therefore fishing operations and trips were identified by the speed patterns, the type of the registered fishing gears and the duration of the operation specifics in compliance with the vessel speeds routinely recorded for the recognized fishing activities. Duplicate records and outliers (GPS errors, reports sent from ports and etc.) were removed to improve the accuracy of fishing trips and operations identification and data mapping; and the pings, recognized as ”start” and “end” of an operation or trip were linked to record time data and coordinates for estimation of trip/operation duration.**

Swept-area ratio assessment

Start-end points of fishing operations were used to reconstruct the trawling paths in GIS. These lines were buffered with the average width (11 m) of the fishing gear and these polygons were clipped with a grid. For benthic habitats a grid layer with cell size 1.0x1.0 km UTM was adopted as an optimal solution. For fish, the assessment scale is grid of cells with size 5x5 km.

At the next step the swept-area polygons were aggregated in each cell to form the indicative layer for surface abrasion and then divided by the area of the grid cell to determine the swept area ratio (SAR).



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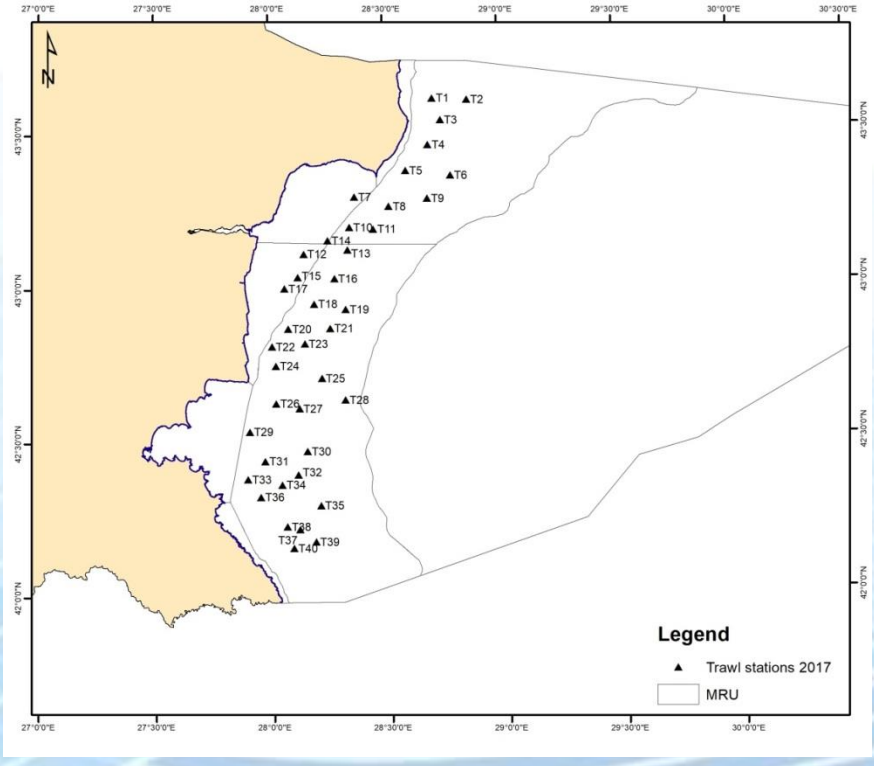
Fish diversity data and status assessment

Sampling was executed during the period 5.10 – 15.11.2017 by OTM trawl gear over 40 stations, distributed in the Bulgarian Black Sea shelf area.



For the assessment, the indicators under the following criteria (COMMISSION DIRECTIVE (EU) 2017/845) are applied:

<u>D3C2 — Primary:</u> The Spawning Stock Biomass of populations of commercially-exploited species are above biomass levels capable of producing maximum sustainable yield.

State indicator:

- **survey abundance indices.**

Fish diversity data and status assessment

D3C3 — Primary: The age and size distribution of individuals in the populations of commercially-exploited species is indicative of a healthy population.

State indicators:

- **the proportion of fish larger than mean size of first sexual maturation – Lm.**
- **the 95th percentile of the fish-length distribution of each population, as observed in research vessel or other surveys (L95).**
- **mean length of fish of each population, as observed in research vessel or other surveys (Lmean)**

Benthic habitats data and status assessment

Sampling for macrozoobenthos was carried out in October 2017 at 107 points. Altogether 238 qualitative samples for macrozoobenthos were collected by means of Van Veen Grab (0,1 m^2).

Brey-Curtis similarity (Bray-Curtis, 1957) on 4th root transformed biomass and hierarchical classification analysis (Clarke et al., 2014) were employed to differentiate macrozoobenthic communities and associate them with the broad habitat types.

M-AMBI(n) (Sigovini et al., 2013) was used to assess adverse effects on benthic macroinvertebrates. The method combines AMBI (Borja et al., 2000), a biotic index based on species sensitivity/tolerance to pressures, with Shannon-Wiener diversity index (H') and species richness (S) as an arithmetic mean of their minimum-maximum normalized values.

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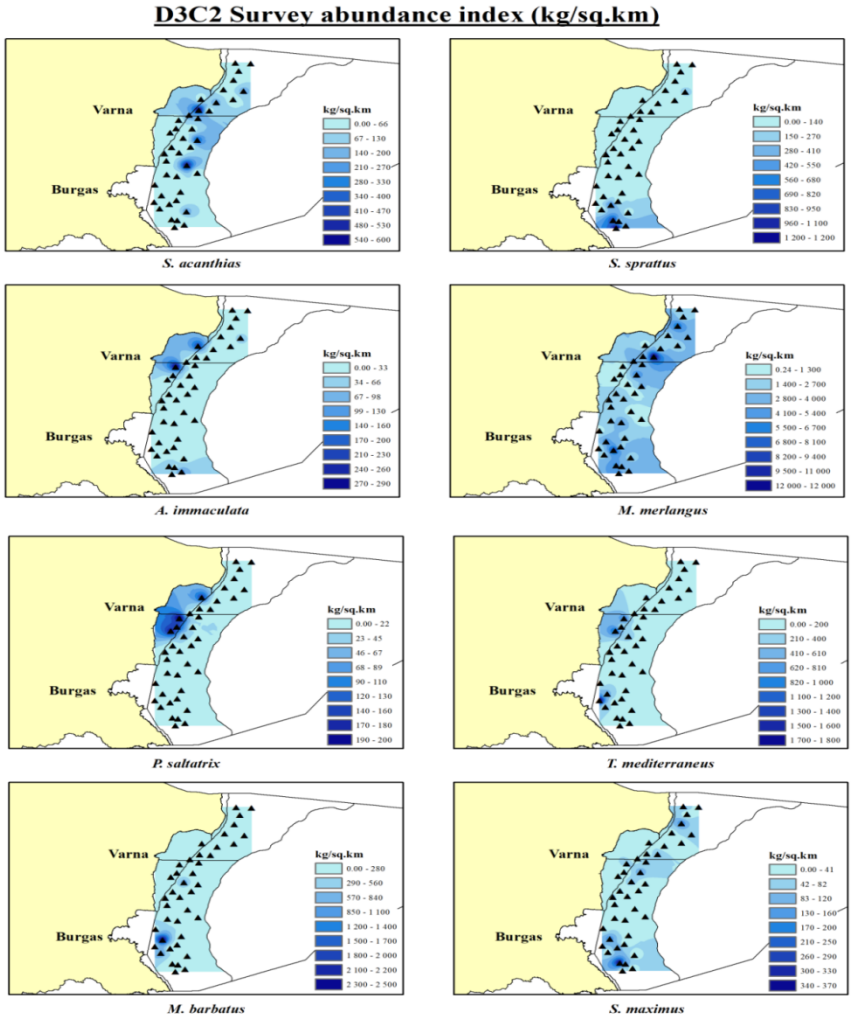
RESULTS

Fish status

The collected data contain information on a total of 28 species of fish that were registered during the survey, of which 11 species are subject to exploitation. Because some of the species were registered in low numbers and at a few stations, the indicators were calculated for only eight of them.

Criteria D3C2, indicator „Abundance index“ (kg/km²)



Abundance indices by biomass (kg.km^{-2}) for exploited fish species.

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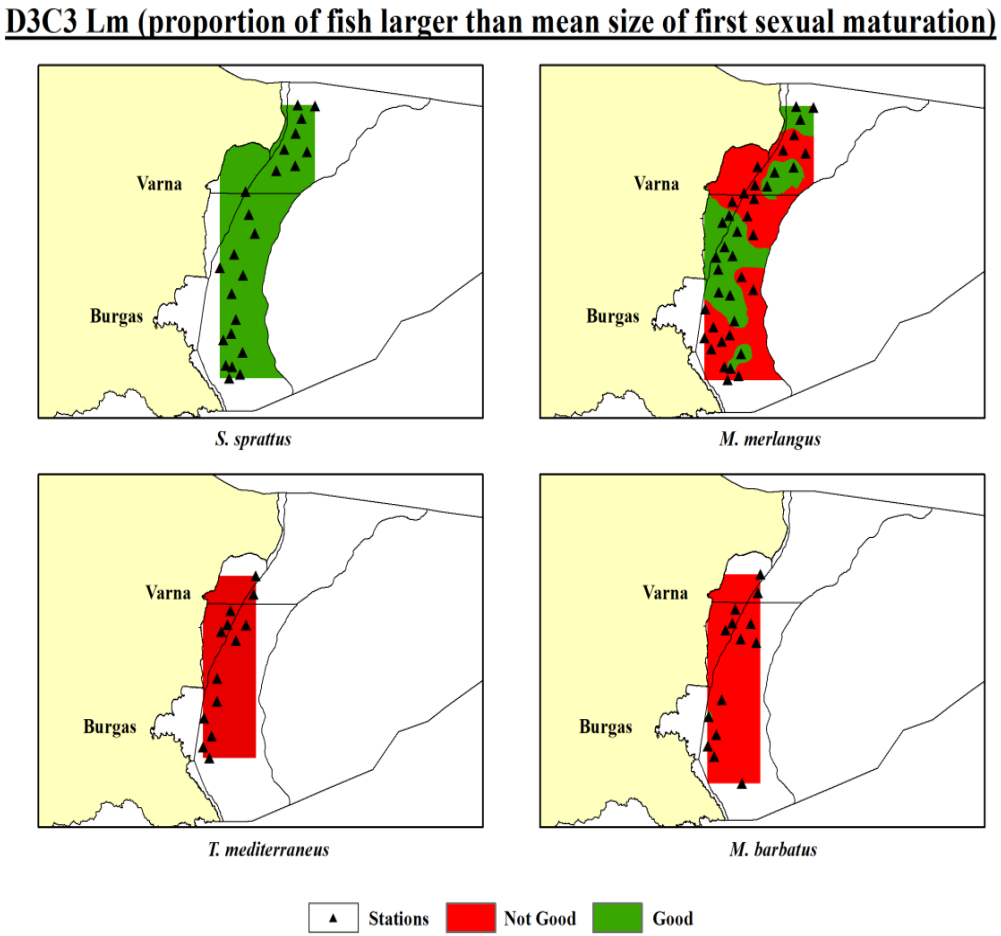
RESULTS

Fish status

Criteria D3C3, indicators:

- the proportion of fish larger than mean size of first sexual maturation – Lm



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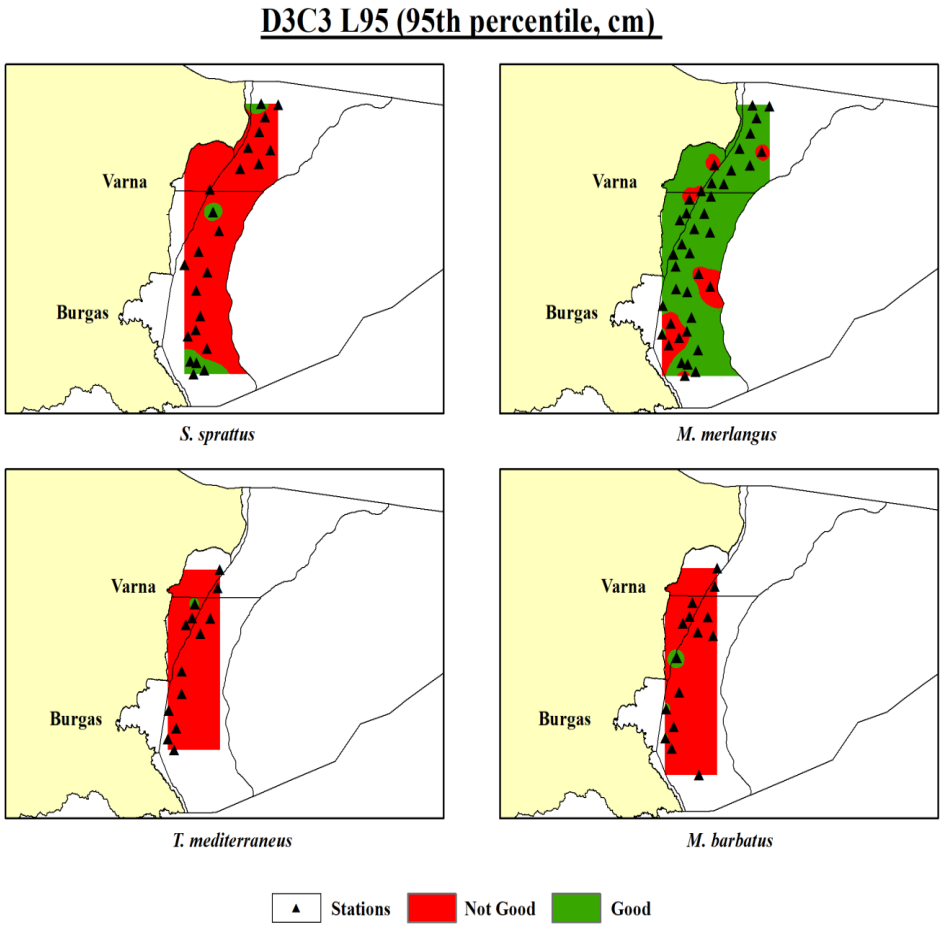
RESULTS

Fish status

Criiteria D3C3, indicators:

- **the 95th percentile of the fish-length distribution of each population, as observed in research vessel or other surveys (L95)**

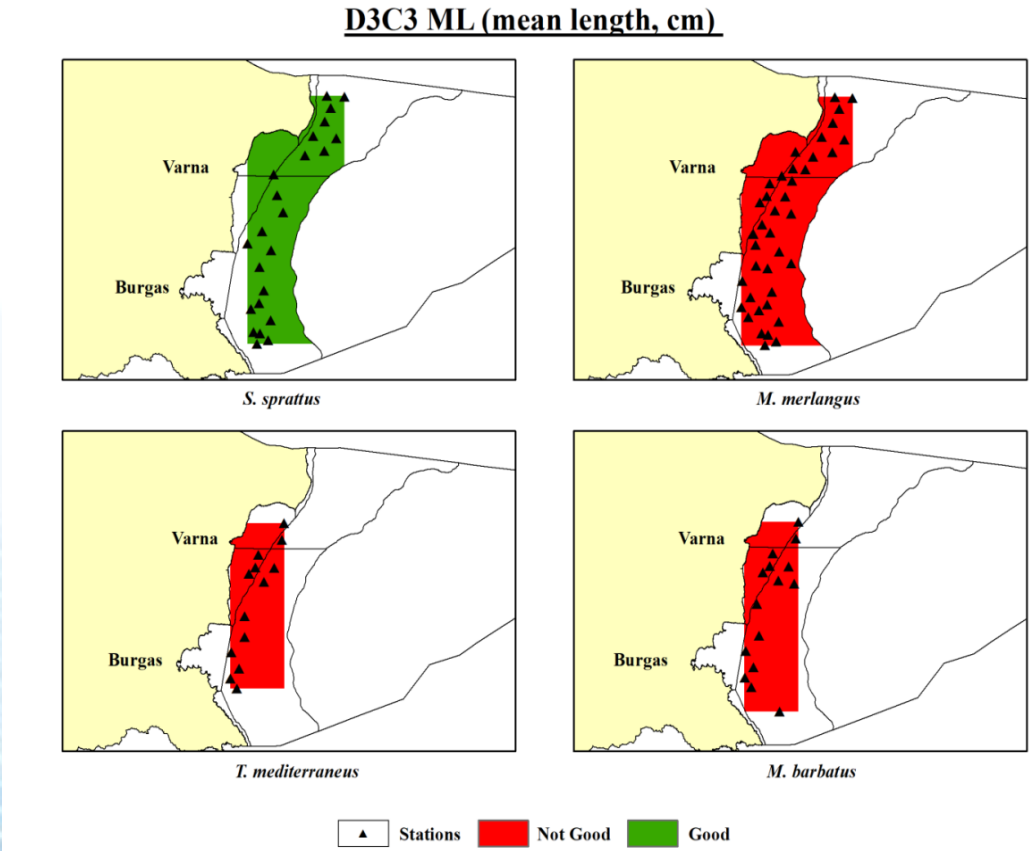


RESULTS

Fish status

Criiteria D3C3, indicators:

- mean length of fish of each population, as observed in research vessel or other surveys (Lmean)



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RESULTS

Habitat status

The taxonomic composition of the macrofauna encompassed 146 species and higher taxa - 50 polychaetes, 28 bivalves, 9 gastropods, 41 crustaceans and 18 miscellaneous (sponges, anemones, nemerteans, turbellarians, oligochaetes, echinoderms and ascidians).

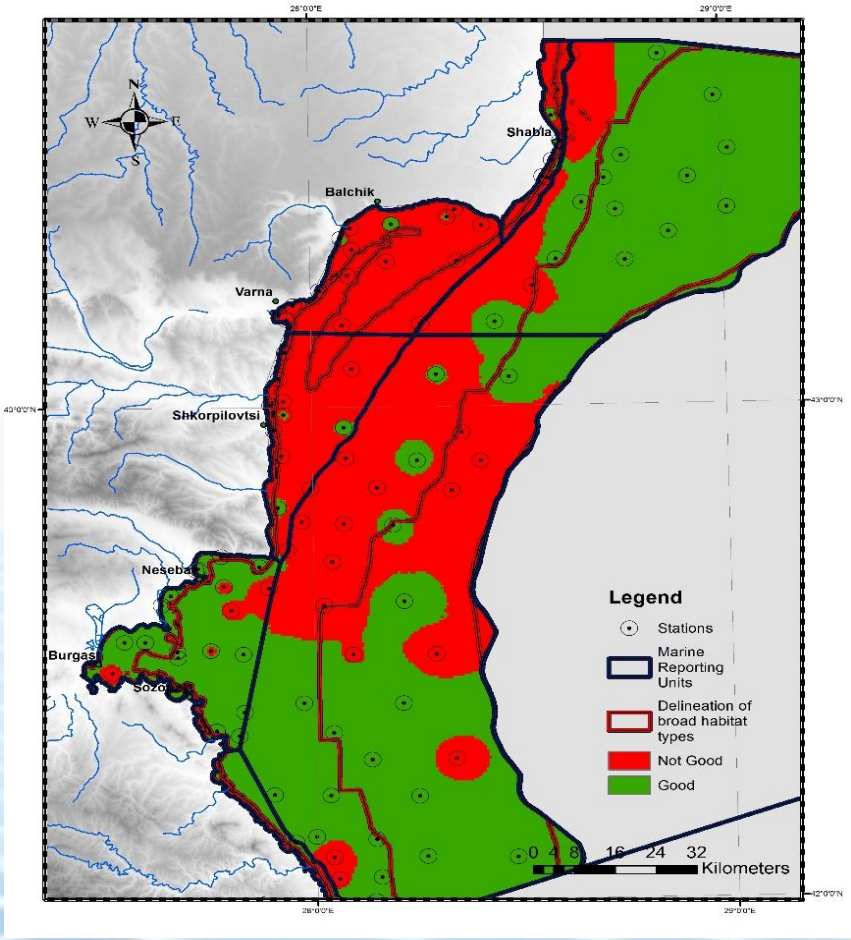
Six biotopes with characteristic communities were differentiated based on Brey-Curtis similarity classification which were allocated to 5 broad habitat types .

Broad habitat type	Biotopes
Infralittoral sand	Upper-infralittoral (1 - 7 m) medium and fine sand dominated by Donax trunculus
	Infralittoral (5-15 m) fine and medium sand, dominated by Chamelea gallina
Circalittoral coarse sediment	Shallow circalittoral (17-35 m) shelly gravel and coarse sand with varied infauna (Modiolus adriaticus, Gouldia minima)
Circalittoral mud	Circalittoral mud with Pitar rudis и Spisula subtruncata
Offshore circalittoral mud	Offshore circalittoral mud with Terebellides stroemi
Circalittoral mixed sediments	Circalittoral mixed sediments with Modiolula phaseolina

RESULTS

Habitat status

The distribution of good and not good habitats condition over the habitats extent in the Bulgarian Black Sea is shown on the figure according to the interpolated results for EQRM-AMBI(n). Generally, the habitats condition of the coastal marine areas between the northern border and c. Emine and the central part of the shelf is not good as made evident on the figure.



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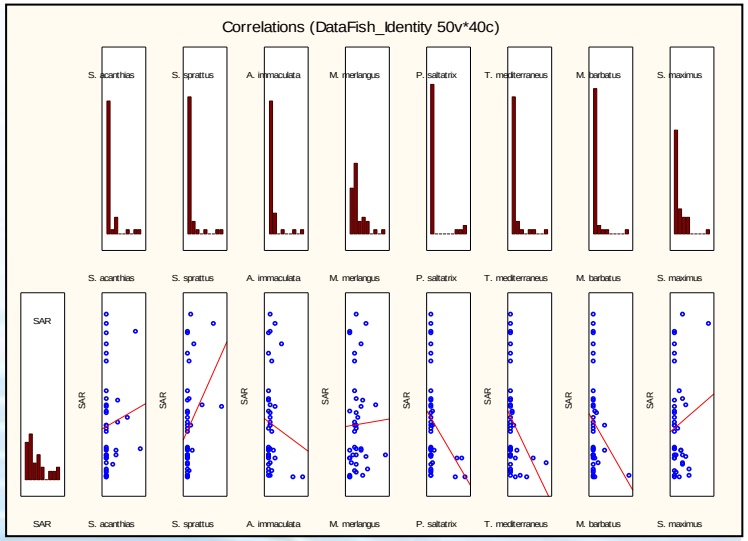
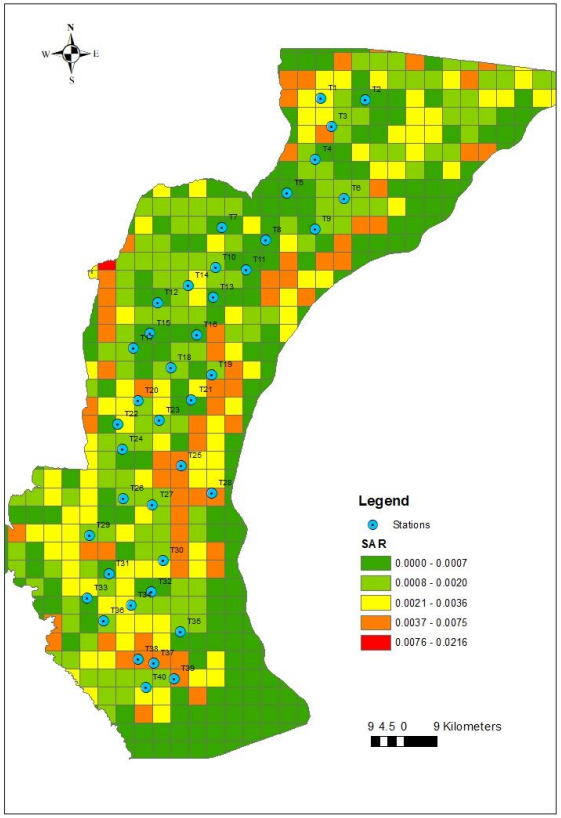
RESULTS

Relationship between the physical pressure and fish diversity

Species biomass	SAR
S. acanthias	0.099978
S. sprattus	0.341372
A. immaculata	-0.106499
M. merlangus	0.027005
P. saltatrix	-0.314823
T. mediterraneus	-0.308366
M. barbatus	-0.225670
S. maximus	0.122227





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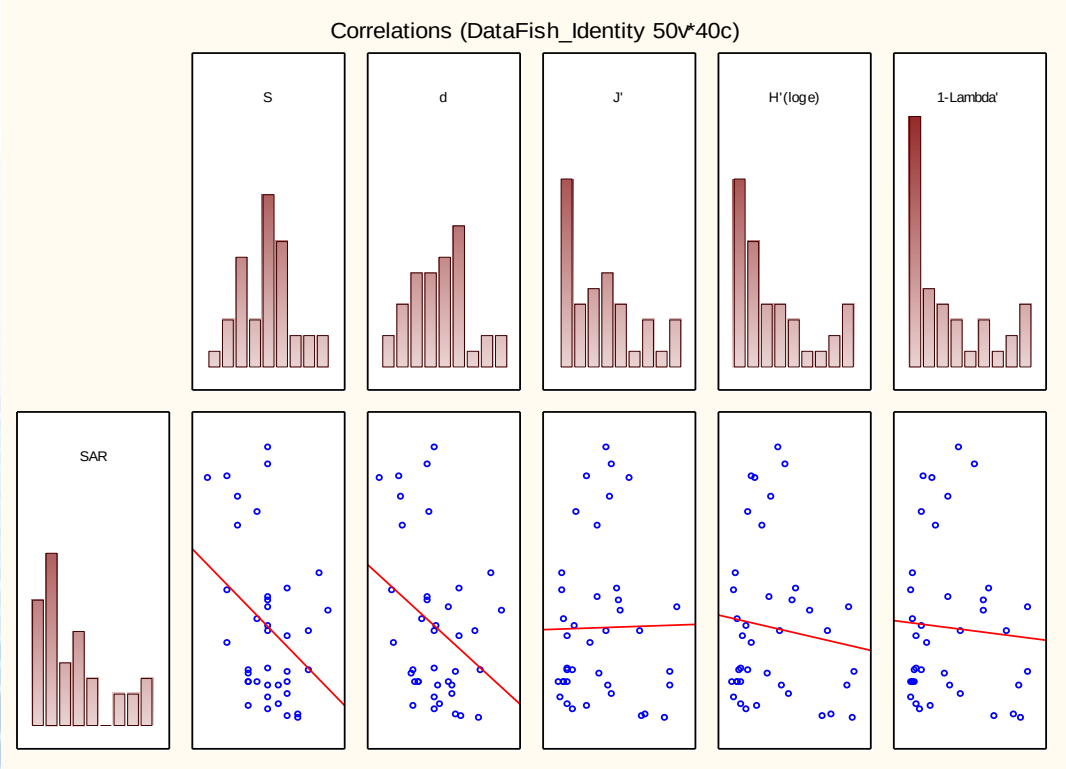
RESULTS

Relationship between the physical pressure and fish diversity

Diversity Index	SAR
S	-0.349710
d	-0.329720
J'	0.015368
H'(loge)	-0.112549
1-Lambda'	-0.063602



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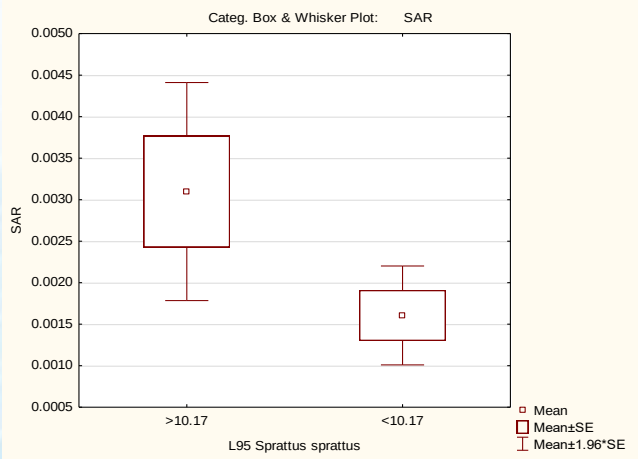

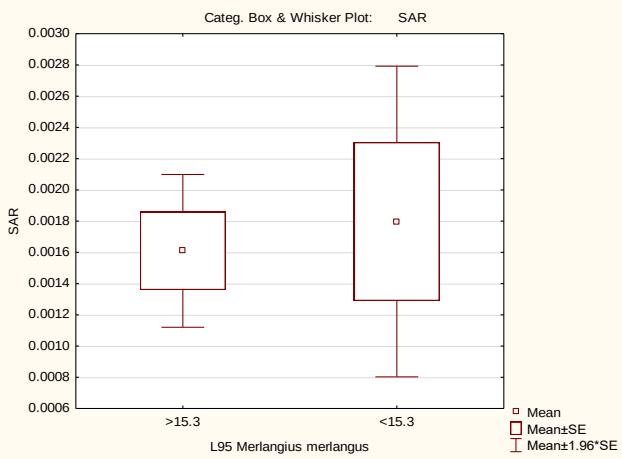

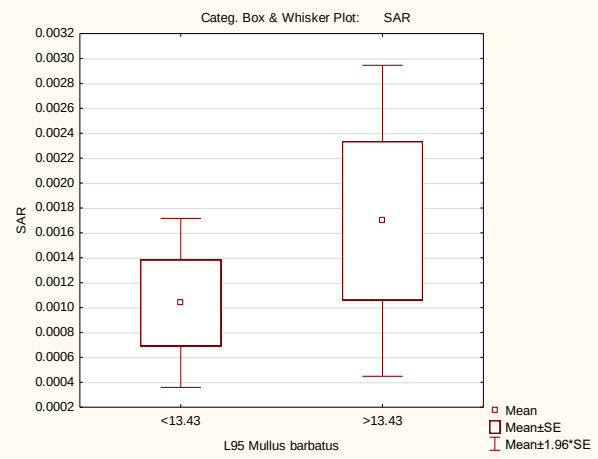

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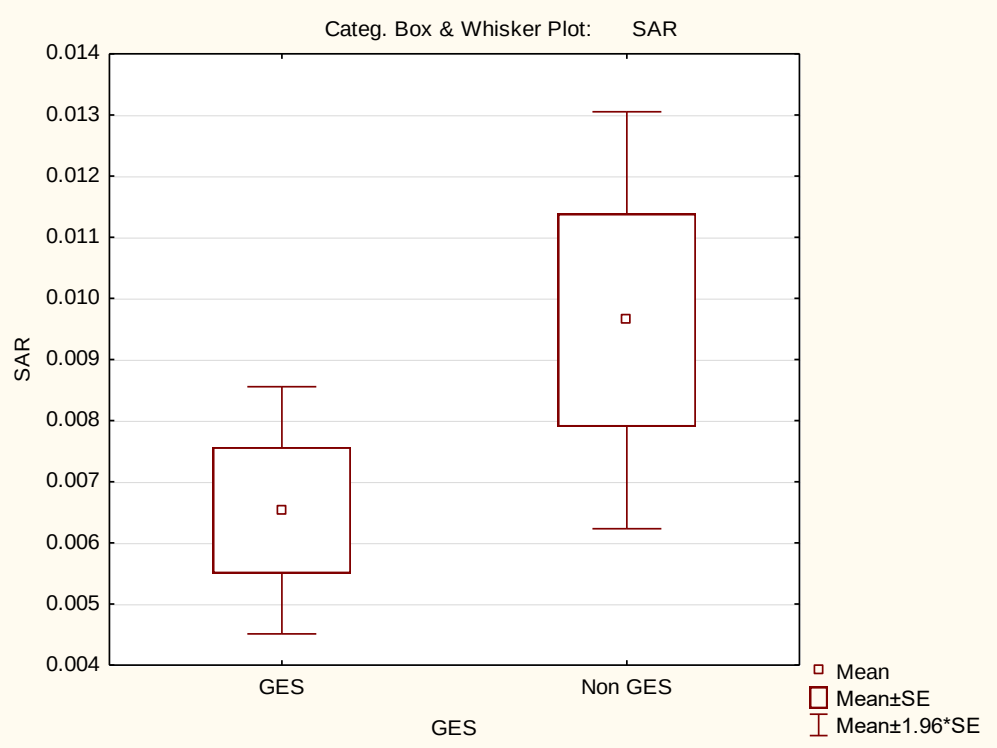
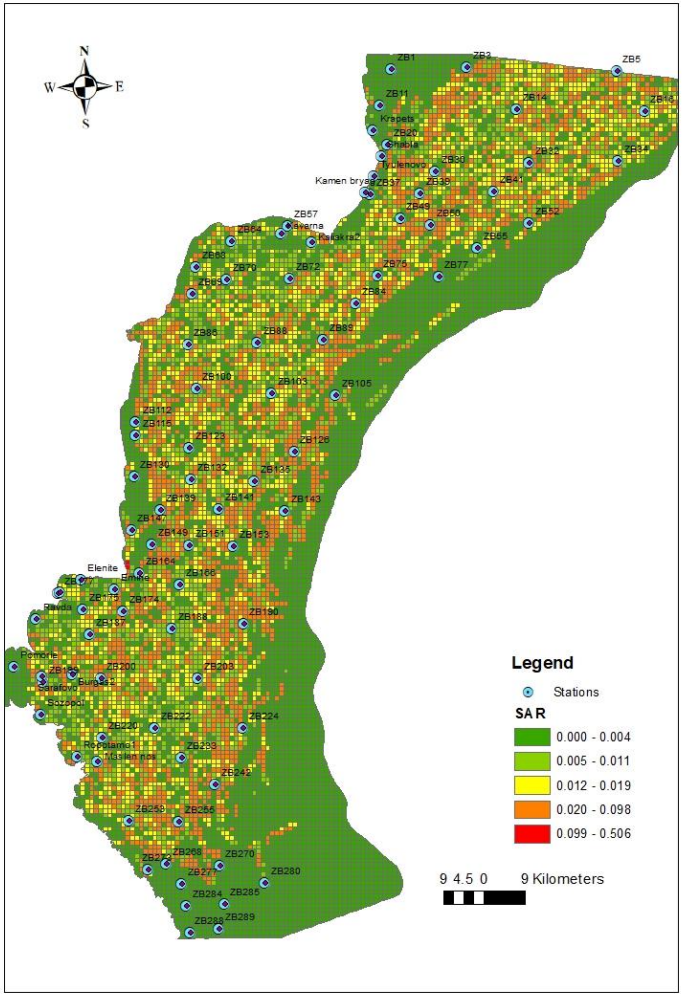
RESULTS

Relationship between the physical pressure and benthic habitats status





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Conclusions and recommendations

- The obtained results show that extensive areas of the Bulgarian Black Sea shelf are subjected to physical disturbance from fisheries, concentrated mostly over the circalittoral seabed at depth 20-70 m.
- The physical pressure is most likely underestimated in the coastal area due to lack of VMS on small fishing boats.
- Significant relationships are demonstrated between the pressure and the status of fish and benthic habitats according to some of the ecological indices used. Although strong correlations were not established, these results are still preliminary due to limited period of only 10-months of physical pressure estimation. Since both fish and benthic macrofauna are long-lived (>1 year - 10 years), to obtain more representative results it is necessary to extend the assessment over a complete 6-years reporting period under MSFD.
- Longevity based indices shall be devised for impact assessment as recommended by ICES advice and by the BSMAG developed in ANEMONE.

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